SATELLITE OPERATOR

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The Kansas City Tracker and Tracker-Tuner Provide Automation for the Satellite Station

You might be surprised how many phone calls we get asking what the Kansas City Tracker is all about. Here we give a description of the unit and it's sister, the Kansas City Tracker-Tuner.

By Bob Myers, W1XT

Developed in the late 1980's, the Kansas City Tracker has undergone several changes since its inception. The purpose of the "Tracker" is to, under computer control, operate your antenna rotator box to turn your antennas. The Kansas City Tracker-Tuner is a different device. It not only turns your directional antennas but adds a feature to tune your uplink and downlink frequency while adding compensation for Doppler shift and setting the transmission and reception mode (FM, USB, etc.). You need to keep in mind that the Tuner is *not* an add-on to the Tracker. *The Tracker and the Tracker-Tuner are two completely different units. If you purchase a Tracker, you cannot add on the Tuner later. You would need to sell your Tracker and buy a new Tracker-Tuner to get the Tuner functions.*

Mechanical installation of the Tracker or the Tracker-Tuner is easy. It plugs into any slot in your computer. The metal bezel must be screwed down to the computer frame as with any other plug in card.

(In some places throughout the rest of the text we refer to the "Tracker" and the "Tracker-Tuner" as one unit: the KCT/T. The tracker function for

(Please turn the page for more)

Stan Oehmen, K7BZ, in Scottsdale, AZ, has been active on the satellites for many years. Stan uses innovation, good antennas, and patience to work OSCAR 13 Mode B. Notice he uses an OSCARLOCATOR, not computer. Ten watts is the power output from the Ten-Tec Mode B box, used in conjunction with the Atlas transceiver located next to the Drake TR-4C. Stan has more that 160 countries on the OSCARs. See some of Stan's handiwork beginning on page 5 of this issue. Photo by W1XT.

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Who Can Use the Kansas City Tracker?

Anyone who wants to automatically point their antennas at a satellite. The Kansas City Tracker is useful for terrestrial DXing and BBS operations. The Tracker is ideal for weather satellite enthusiasts who use directional antennas.

Who Can Use the Kansas City Tracker-Tuner?

The Tracker-Tuner is best suited to digital satellite operations such as OSCARs 16, 18, 19, 20, 22 and 23. It is also very useful for Shuttle and Mir work. And it simplifies operations with OSCAR 21.

When would a Tracker or Tracker -Tuner be unnecessary?

Omni-directional antennas don't require a rotor. SSB and CW operations are usually conducted by manually tuning the station transceiver. High altitude satellites (OSCAR 10 and 13) can be followed with directive antennas by manually adjusting the control box every 5 or 10 minutes, and sometimes even less often.

both units is identical. Only the Kansas City Tracker-Tuner will, in addition to pointing your antennas correctly, tune your transceiver through its computer control circuitry.)

How fancy do I need to be?

Adding the KCT/T to your satellite station is a big step toward station automation. The satellite operator must decide if automation is desirable or even necessary, and if so, how much automatic operation is really needed.

As an example, let's look at K7BZ, shown in the photograph on page 1. Stan operates OSCAR 10 and 13, Mode B only. And he doesn't use a computer in his setup. K7BZ has little or no need for a Tracker.

Stan has built an unusual antenna for his OSCAR 13 uplink, as shown in a photograph later in this issue. Because the pattern of this uplink antenna is very sharp in the vertical plane, perhaps a Tracker (and computer) would be useful. But it certainly isn't necessary. K7BZ is not interested in using a transceiver with computer control capability since he works only CW and SSB. Stan would have no use for the Tracker-Tuner. OSCAR 13 moves, for the most part, very slowly in the sky as viewed from the ground. Even a sharp antenna array can be pointed easily by hand operation of the rotor control. Someone with Stan's operating interests would not need or want a KCT/T.

Do "I" need one of these for OSCAR 13?

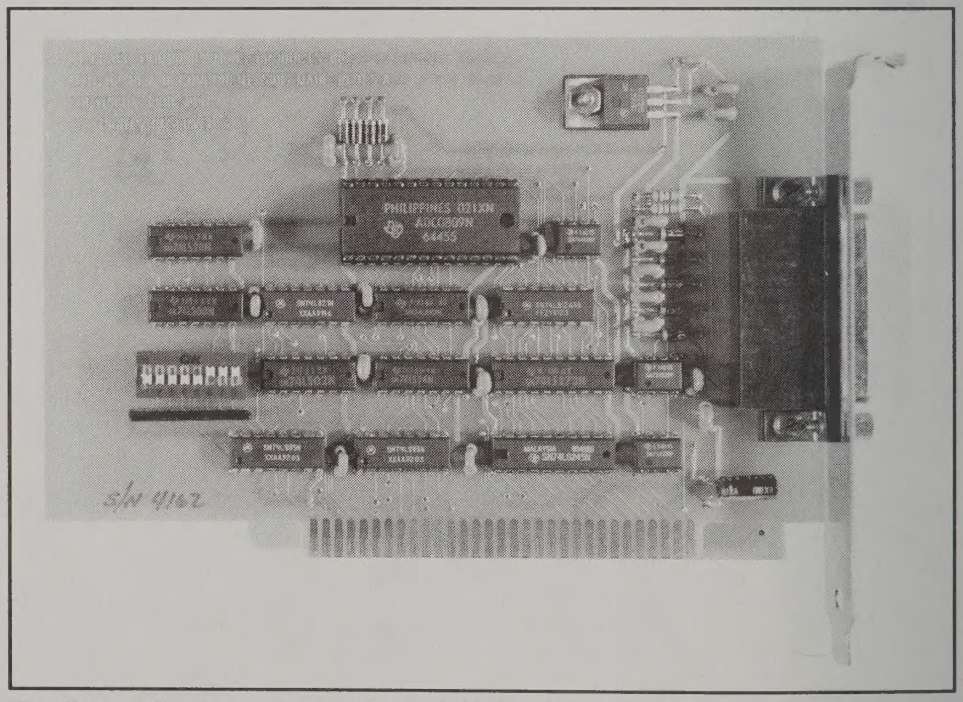
You need to first consider how you are operating the satellites now and perhaps where you would like to be over the long term. For OSCAR 13, a Tracker is very handy but not necessary. If you are working SSB and/or CW, the Tracker-Tuner version is not needed since the operator generally wants to tune his/her own uplink and downlink manually. If two stations are each using a Tracker-Tuner at their end of a QSO, and both are properly set up, the Tracker-Tuner will keep both stations on the same apparent frequency automatically. Very few, if any, OSCAR 10 or 13 operators do that.

Because OSCAR 10 and 13 signal strengths are somewhat low, almost every station is using a steerable antenna system with high gain and a relatively narrow pattern. The Tracker, used with a computer, lets the operator forget about manually adjusting the rotor control box for pointing the antenna. With bigger satellite antennas, a higher degree of accuracy is needed and adjustments should be made more often. Since keeping up with tracking chores on high-flying satellites like OSCARs 10 and 13 doesn't require a lot of attention from the operator, the Tracker offers more convenience and accuracy than anything else.

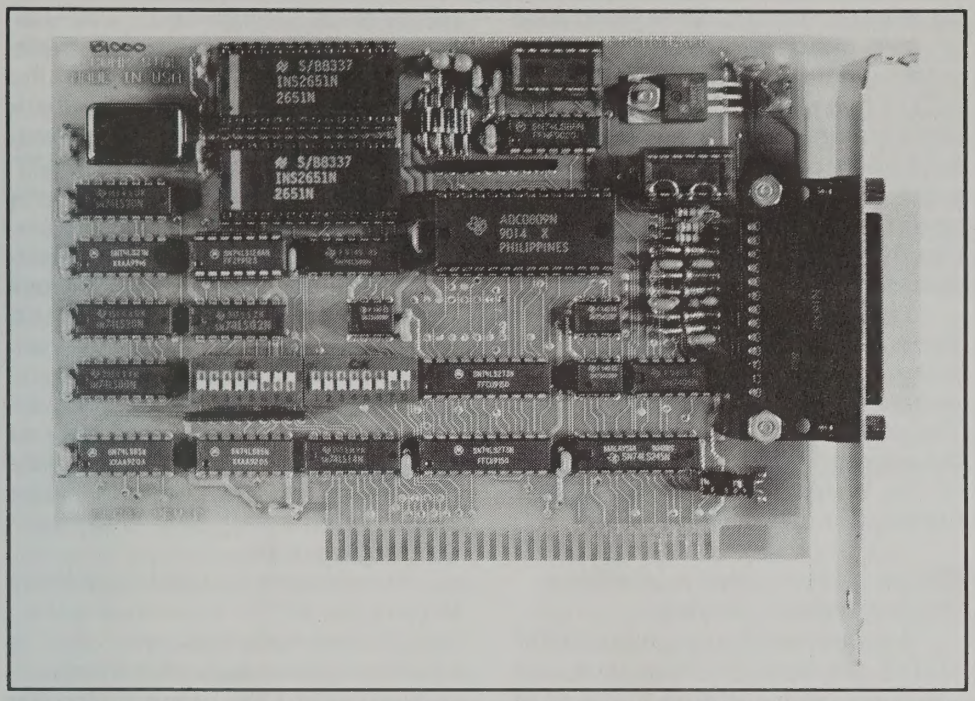
How about the Microsats?

Low Earth Orbiting (LEO) satellite operations benefit greatly from the use of the KCT/T. An LEO satellite moves swiftly across the sky and if the operator wants to do much more than keep up with the pointing chores, he/she might want to use at least a Tracker and computer.

Where the KCT/T really comes into play is with the digital satellites. Since a computer is necessary for



The Kansas City Tracker plug-in board. Notice that there are fewer components on the Tracker than on the Kansas City Tracker-Tuner shown on the next page. The photo shows the board at 65% of it's actual size. The unit plugs into any one of your computer slots (PC compatible) and is easy to align using the INSTALL program. Alignment is required so the unit can compensate for variations in line length to the rotor and voltage differences. Photo by W1XT



The Kansas City Tracker-Tuner plug-in board. The photo is 65% of it's actual size. It's easy to see that the Tracker on the previous page is not "upgradeable" to the Tracker-Tuner. They are different products. Note that on this board, the relay driver diodes have been unsoldered and the jumper plugs have been installed in place of the RS-232 level converter chips that were removed. This Tracker-Tuner is to be used with an ICOM-970 and Yaesu G-5400B rotor but the same configuration would be used with the Yaesu FT-736 and the same rotor. Photo by W1XT.

digital packet operations anyway, why not put it to work to tune the receiver, set the mode, and point the antennas as well. Because OSCAR's 16, 19, 20, 22, and 23 are all LEO satellites as are Mir and the Space Shuttle, the KCT/T offers significant benefits to the operator. The KCT/T operates in the "background" without need for any attention after it is loaded, freeing up the computer to run satellite packet software (PB/PG).

OSCAR 21, the Russian DSP FM "repeater satellite," moves quickly across the sky, too, and having a KCT/T direct your satellite antenna system is very helpful.

If all your work is on OSCARs 16, 20 and 21, you may not even need directional arrays. Obviously you don't need a Tracker if you use fixed omni-directional antennas. And with 1200 bps PSK digital satellites, such as OSCARs 16 and 20, your PSK modem usually has the capability to tune the receiver through its up/down circuitry, so the Tracker-Tuner wouldn't be needed either.

But don't be fooled. Once you are up and running on OSCAR 16, you'll probably want to move on to the 9600 bps Birds. All of the digital satellites are Mode J (uplinks on 2 meters and downlinks on 435 MHz) except Mir and the Shuttle operations. The maximum Doppler shift is about 9 kHz above and below the center frequency. Running without a device that will tune your receiver automatically, such as the Tuner portion of the KCT/T can be a little difficult because the frequency changes quickly.

If the operator wants to use his/her OSCAR 13 directional array on the digital satellites, the KCT/T becomes a handy piece of hardware. Errors in pointing are kept to a minimum. Indeed, if your Keplerian elements are up to date and you keep your computer clock right on the money, there are likely not to be any significant pointing errors at all.

How do the Tracker and Tracker-Tuner work?

The KCT/T operates as a TSR (Terminate and Stay Resident program) in your computer. That means it is loaded and then disappears until called on to perform some function. In a typical setup, it is loaded at the time you boot your system. Except for the fact that the KCT/T consumes some memory, you can go about your business with the computer doing other things with no interference from the KCT/T.

In the simplest of terms, a satellite tracking computer program, such as RealTrak or QuikTrak, is used to generate what is called a time-target (time and target) table. (More on tracking programs later.) The time-target table is a list, as you might expect, of specific times and the pointing directions toward a specific satellite, which you load into the computer's active memory. The KCT/T then reads this table and points the antennas in accordance with the information in the time-target table. The Tracker-Tuner also calculates the Doppler shift in frequency based on your initial setup within the Tracker-Tuner program. The beacon frequencies for each satellite are used for the calculation.

From the Tracker, data is fed to your antenna rotor control box to set the azimuth and elevation. In the case of the Tracker-Tuner, it feeds pointing data to the rotor control box but it also sends data to the receiver's computer frequency-control-input connector. Even with an uplink on

Where Can I Buy a Kansas City Tracker?

In our effort to provide an easy way to buy satellite components, both the Kansas City Tracker and the Kansas City Tracker-Tuner are available as part of our broadening line of satellite products. Please order from R. Myers Communications, P. O. Box 17108, Fountain Hills, AZ 85269-7108. We accept VISA/MasterCard and you can order by phone: 602-837-6492, FAX: 602-837-6872, or by mail anytime.

The price for the Kansas City Tracker is $229 plus shipping. The Kansas City Tracker-Tuner is $319 plus shipping. Shipping to the U.S. and Canada is $10 which includes insurance. Overseas buyers need to contact us for shipping and insurance costs on a case by case basis.

one band and the downlink on another (which is most of the time), the Tracker-Tuner will adjust each frequency in a predetermined sequence.

Is the setup difficult?

In a word, no. The first thing you do is make a duplicate copy of your original disk and then put the original away in a safe place. Both the Tracker and Tracker-Tuner use the same software. Setup for the Tracker functions comes first. You go through a menu driven procedure which writes directly to your floppy disk. (That's why you copy the original and put it away!) If you ever want to change the installation, you'll need to go back to the master.

The INSTALL program goes through a calibration procedure so that the Tracker knows where 0 and 90 degrees of elevation are (or 180 degrees if you want to "flip" the array for overhead passes) and where the 180 degree azimuth points are (for a North centered rotor). All of the installation is done on the duplicate diskette. When INSTALL is completed, the files are loaded from diskette to a directory you create on your hard drive. The INSTALL disk becomes your backup.

A few command lines need to be added to your AUTOEXEC.BAT file if you want the KCT/T to load when the computer is turned on. Additional command lines need to be entered for the "hot keys" to work. Hot keys are keyboard entries which activate pop-up menus on your screen to tell you what the KCT/T is doing at any given time. For instance, <ALT-O> pops up the rotor status on the screen while <ALT-P> displays the Tuner status. ESC makes them disappear. The instruction manual gives keystrokes exactly as they need to be entered.

For the older KenPro rotors or for the present Yaesu G-5400B rotor (essentially the same unit), the KCT/T is plug and play. A cable is supplied with a DB-25 connector on one end for attachment to the KCT/T. (This is not a serial port cable and cannot be used as such). On the other end of the cable is a plug for insertion directly into a jack on the rear of the Yaesu or KenPro rotor control boxes. It's as simple as that for these popular rotors.

The instruction manual describes suitable methods of connecting to other rotor combinations. It takes a bit of work, though, since you'll need to wire together a set of relays to activate the rotor's control box. The KCT/T is equipped with relay drivers already installed on the board for this kind of operation. In fact, if you are going to use the Yaesu rotor, you'll need to disable the relay drivers, as clearly defined in the instruction manual.

The Tuner part of the Tracker-Tuner unit requires the installer to make up a cable to go between the receiver and the DB-25 connector. The correct pins can be identified in the appropriate Appendix at the back of the instruction manual. Yaesu hookup is different than ICOM.

How accurate do I need to be with my time and Keplerian elements?

A recommendation made in the KCT/T manual (the manual is the same for both units) is to set your computer clock to UTC. While it is easy to compensate for UTC to local time in the command lines as outlined in the manual, one must remember to change these at Daylight Savings Time. With Amateur Radio generally using UTC and most tracking programs using UTC, it makes perfectly good sense to use UTC on the computer clock and avoid all the hassles of time conversions for various programs. Let your clock on the wall show local time!

The KCT/T gets it's starting time from the computer's clock when the computer is turned on. From then on, the KCT/T keeps its own time. So if you need to adjust the computer's clock or date, you need to reboot the system to reset the KCT/T clock. Obviously, if your computer is on one time, and is being used as the clock source for your satellite tracking program, and the Tracker device is on a different time, there will be inaccurate information fed to the antenna pointing hardware.

The computer at W1XT loses about 28 seconds a day. Depending on the satellite and the position in the sky, that 28 seconds can cause some pointing error — too much error for this operator to be happy. It is easy to set the computer clock. At least once a day, WWV is tuned in on an HF receiver and the computer's time is corrected. That reset is followed by a reboot of the system. It's usually done at first turn-on for the day.

The age of your Keplerian elements is important, too. With OSCAR 13, for instance, updated elements once a month will be fine. For LEO satellites, every two weeks is probably a good idea. Some may argue with that point, but at W1XT, there is concern for cumulative error when the antennas are under computer control. If the Keplerian elements are off a bit, the tracking program can be slightly off the mark. And if the computer clock is off a bit, it further disturbs the tracking program accuracy and the KCT/T's accuracy. Keeping Keps and time as close to on-the-money as possible reduces cumulative error and gives one a good feeling that things are working correctly.

You can set the tracking program to have the KCT/T reposition antennas at any increment you like by establishing the time interval between entries in the time-target table. For OSCAR 13, five or ten minute intervals might be fine most of the time. For UO-22 or KITSAT (KO-23), when used with a large satellite antenna array (narrow pattern), intervals of 6 seconds (or less) are not unreasonable (0.1 minute). You want to be sure the satellite doesn't get ahead of the antennas during a near-overhead pass. (See the section on tracking programs later.)

Space Shuttle missions and SAREX operations require a high degree of accuracy in the computer's clock and a very recent set of Keplerian elements. The Shuttle orbit is rather low and moves quickly across the sky. For Shuttle operations, six second updates to the KCT/T and daily Keplerian element revisions are recommended. Remember, the Shuttle, as in the case with the Russian space station, Mir, can and does maneuver in orbit.

Is it really as much work as it seems to use the Tracker or Tracker-Tuner?

No. It actually simplifies station operations. Multiple satellite passes can be loaded to the KCT/T's time-target table. Even multiple satellite passes can be loaded. If you are using the Tracker-Tuner and set the Tuner frequencies and modes properly for each satellite, you'll have a certain double check that things are in order. The loaded time-target table establishes the satellite name, the uplink and downlink frequency, the mode for the uplink and downlink (even if

they are different), Doppler shift, and the antenna position.

If you track more than one satellite each day, you know how you need to assure that all the above items are right. Or, you'll miss a pass. The Tracker makes sure your antennas are pointed correctly. The Tuner sets the transceiver properly. It's a large benefit for simply keeping your clock on time and your Keps up to date.

How do tracking programs work with the Kansas City Tracker?

Computer programs, such as RealTrak and InstantTrack, can communicate with the Kansas City Tracker and Tracker-Tuner. They do so with *software interrupts* that are not noticeable to the user of the software.

For antenna control the KCT/T receives commands from the computer in two formats. First, real time tracking is performed by continually sending to the KCT/T updated target azimuth-elevation points. In InstantTrack, these commands are routed through a separate TSR called OrbitDRV that must be loaded separately from the main program. RealTrak drives the KCT/T interface directly. In both programs, the software calculates the satellite's position and tells the KCT/T where to point. The KCT/T takes care of the rest.

You probably will want to use your computer for some task besides satellite tracking, such as logging, rig control, or perhaps communicating through the digital satellites. OrbitDRV, properly configured, can run as a "background" autotracker for a single satellite after InstantTrack is terminated.

RealTrak takes "background" tracking a step farther. It uses the KCT/T "table mode" facility to permit background tracking of one, *or several,* satellites after exiting the program. You simply fill the KCT/T table, which is a list of satellite time/az/el information in the computer's memory, at whatever increment is appropriate. For OSCAR 13, entries might be 5 or 10 minutes apart, whereas for FO-20, you might want a new entry in the table every 3 seconds, as mentioned earlier in the text. You can load the next pass of a single satellite simply by pressing <ALT-F> (for "Fill the table"). Or you can automatically load an optimized series of passes for up to 10 satellites by using RealTrak's Priority List Tracking function. Pressing <Ctrl-PgUp> lets you set the parameters for passes to be included in the list, such as minimum elevation or pass duration. One more keystroke and the table begins to load. Once the KCT/T table is loaded, a process that usually takes only a few seconds, you can exit RealTrak. The KCT/T will read an entry from the table every few seconds (or minutes) and will keep your antennas aimed while your computer is doing something else. Your antennas will track each satellite in the list, pass after pass.

What else can I do with the KCT/T

There are a few other things that can be done with automatic aiming and radio tuning. For instance, it is possible for a BBS control operator to set up a file to aim directional antennas over certain paths automatically during the day. And for DXers, there is a special call sign aiming program that comes with the Tracker, but we have not put that to a test at W1XT.

Vision impaired Amateurs can have antennas automatically pointed. And, since the KCT/T has CW output to announce status and positions, the operator is able to determine what's going on while it's happening.

Are there any problems?

Although we hear complaints about the instruction manual, everyone seems to be able to plow their way through it. There's little question that the manual needs some revision and more "friendliness" built in.

The Tuner drives the Yaesu FT-736, the Kenwood TS-711/811, but not the TS-790 on OSCAR 13. The TS-790 works on all other satellites. The ICOM IC-271/471 needs ICOM's interface, but the IC-275/475 runs directly from the Tuner without it. The IC-970 is not working at the moment; the Tuner will set the mode and change tuning from the main to sub-band receiver, but it won't set the frequency. It's a small bug in the software, only a day or two from final fix. If you have a '970 and want an update, call, FAX or write us.

Several users have reported having problems getting the Tuner portion of the system operating correctly. Although it is mentioned in the manual, it's not too clear that the Tuner version is shipped from the factory set up for RS-232 level inputs and outputs.

Most radio control ports are TTL level. Then the manufacturers sell you an expensive accessory to convert TTL to RS-232 voltage levels. You don't need that accessory. But you must exchange two ICs with two jumper plugs on the Tracker-Tuner circuit board before installation. The jumper plugs are supplied and instructions are given in the manual. The swap takes only a few minutes. If you don't make that change, the Tuner is guaranteed not to work with your radio.

A caution must be offered when using automatic antenna turning devices such as the KCT/T. Be sure you have electrical and mechanical stops on the rotors. This is especially necessary if you are not going to pay any attention to the rotor control box while the automatic function is operating.

With the KCT/T, if you shut down or reboot your computer while the antennas are turning, there is nothing to tell the rotor to stop turning, and the rotors will run all day long unless you have both electrical and mechanical stops. If you don't have electrical stops, the mechanical ones, like the coax, will cause burn out of your rotor motor. Not good. You can do a lot of damage to your antenna system.

Another "happening" that can cause damage to your system is having something hang up or "catch" your antenna when it is turning. For instance, a growing tree limb comes out and stops the rotor during operation. With any automatic rotor system, the motor is energized until the proper azimuth or elevation is achieved. If something fouls the system, you're in for trouble. Make it a habit to look over the antenna system regularly to assure no hardware has come lose and nothing has tangled the coax.

There have been several sad notes on the Microsats describing these kinds of problems. If you must reboot while the antennas are turning, turn off the power to the rotor control box. If the entire station undergoes a power interruption, of course, the rotors will stop anyway. Fortunately, rotors like the Yaesu G-5400B and the KenPro do have both kind of stops. But that doesn't protect you from something accidently hanging up rotation at mid range. ♦♦♦

A Very Weak Signal Source for 145 MHz Preamp or Antenna Testing

Have you ever had need for a weak signal generator for the middle of the satellite band on 2 meters? Here is a simple circuit that can be put together in a matter of a few hours and a trip to Radio Shack.

By Stan Oehmen, K7BZ

This low level signal source can be used to check OSCAR 13 and other receiving systems for gain and signal-to-noise ratio.

When the generator is set about 30 feet from the receiving antenna the signal is about S7. The receiving antenna can be off-aimed to set the level down to the noise or the oscillator can be moved further away. The antenna ends are formed to permit hanging it on a fence or from a tree branch.

The crystal is a surplus FT-243 from an old 2 Meter transmitter. The output frequency is approximately equal to the 18th harmonic of the frequency marked on the crystal holder. In this case, 8.105 MHz.

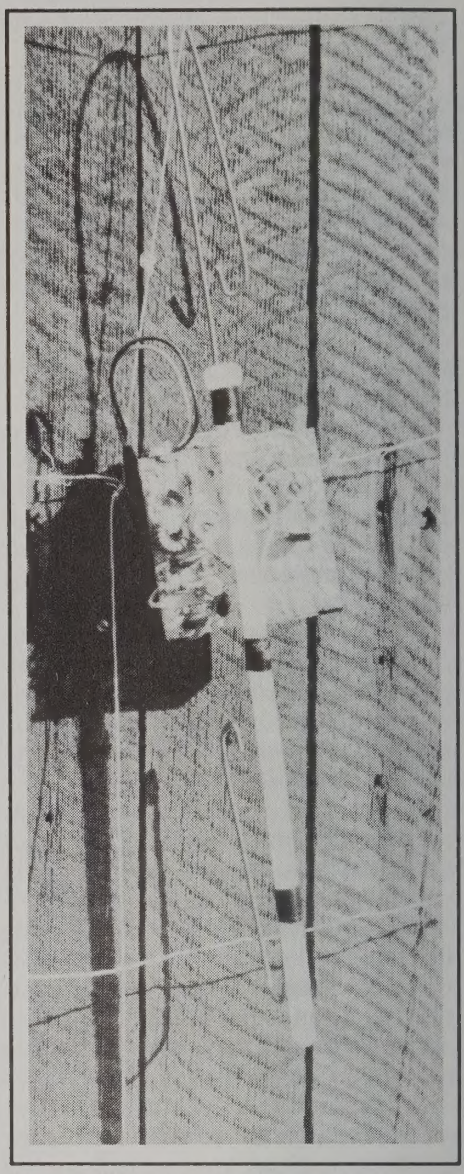
At 9 volts, the generator draws 2.5 mA. The multiplier stage has no collector voltage so the output is very low but can be peaked with a spectrum analyzer or your receiver.

Editor's note: If you're wondering what actual testing you can do with this little device, here are some ideas from a conversation with Stan:

First, place the oscillator far enough away from your satellite antennas to give you a signal level just above the noise level of your receiver. Set it up with your preamp turned off so that it is out of the feedline path to the receiver. (That doesn't mean in the feedline path with voltage removed.) Adjust the signal level by moving the oscillator or antenna position to where it is at the edge of unreadable. Then put the preamp back in the line. Don't change anything else. You may get a big surprise.

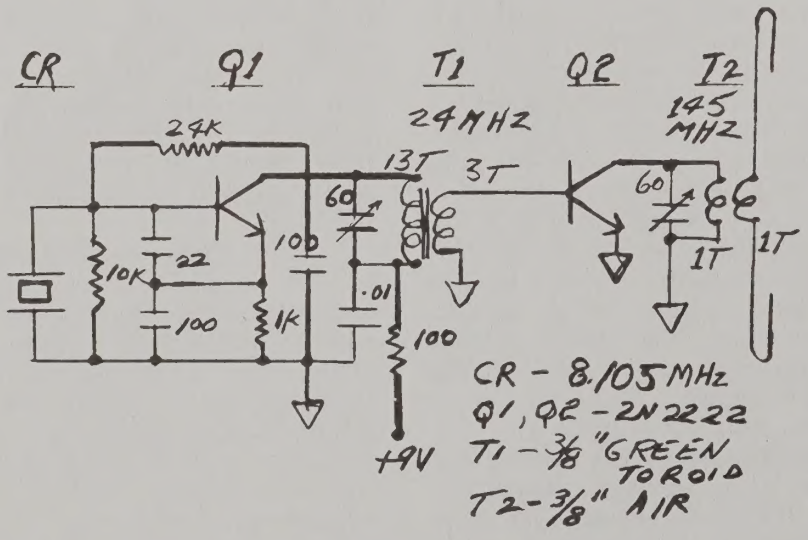
Listen to the difference between the signal and the noise when placing the preamp back in line. Don't worry about how high the S-meter reads. It will read lots higher with the preamp turned on. You may find that the noise level comes up more than the signal does when the preamp is put back in line, making the test signal unreadable. If this happens, you have a preamp problem. If your signal rises quite a bit out of the noise, as compared to before, then your preamp is doing its job.

(Continued on page 12)



The oscillator is built on a surplus piece of copper board. There are no frills — not even an on-off switch. Unclip the battery when the device is not in use. Forget and you'll have a dead battery the next time you go to use it! The oscillator is shown here hung over a garden string running along a wooden fence. The plastic rod keeps the bottom half of the short antenna in place and fits into a small wooden stand that was built for the times there is nothing for the "hook" to use as a support.

Very Low Level Signal Source



Drawing by K7BZ

More on Microsat Operations

As each week passes by, we learn more about the 1200 and 9600 bps Microsats. Some observations are given here for the benefit of those who are trying to get started, those not quite there yet, and those who need some motivation to get going.

By Bob Myers, W1XT

There is so much information on the 9600 Birds, UO-22 and KO-23, that it is almost impossible (if not completely impossible) to digest it all. This, the third part in a series of who knows how many, will touch on some of the general points and observations by this relatively newcomer to the 9600 bps satellites.

During the past several weeks, little work has been done on OSCAR 16, although that satellite should not be overlooked. It is relatively light with activity and has very interesting files concerning solar activity and operating computer utilities along with lots of mailbox traffic.

Automation

The more you work the Microsats, the more you realize that automation is necessary. You really need to be able to set up the passes you want to catch for the day, and then let the system go capture the data. When it is done, you can take a few minutes and sift through directory listings to see what files you might want to download. Mark them appropriately and during the next set of passes, the system software will download most, if not all, of the files for you. If you want to respond to a message on the system, you can do that too. The next pass you can set the system to upload your files automatically before downloading new ones.

If you add to the time it takes to "sift through the files," the time you devote to manually tuning the receiver, etc., you'll need to be retired and spend a good part of each day just extracting and looking at data. Automation is necessary with the 9600 bps satellites or you become a slave to them. The only other solution is to not look at many files, or just look at files addressed to you specifically. But that may not be as much fun!

Uploading files

Sending files to the Microsats is fun because of the way it automatically does everything while you just sit and watch. The process is simple.

Create your file in a text format (no word processing characters). Be sure to include line returns at the end of every line, and save the file (as ASCII characters) in the directory you have designated for PB and PG.

Here is a GIF file sent to W1XT by KB2MVN. On the computer screen, it is full color and very striking. As reproduced here, a lot of the high quality is lost. It's almost an electronic QSL card! The image consists of six pictures put into one and then digitized for transmission via KITSAT 23. The antennas (lower left) and the home (lower right) are quite sharp in the screen display. And of course, we get to see KB2MVN himself. The file was 143k in size and took two relatively high passes of KO-23 to download it completely. See the text for more details. Photo by W1XT.

Then you need to do a few operations on the file. The general guide line is that files over about 2k should be compressed. The most popular compression method on the Birds is PKZIP, but others are used. If your file is less than 2k, no compression is needed, although compression does save memory space on the spacecraft. For compression, just run PKZIP.

Next, you need to add a Pacsat file header to your text file so that the satellite knows what to do with the file. It is here that you specify who the file is being sent to, from whom it is coming, what kind of compression, if any, is used, and how long the file is to remain in the satellite's memory (up to 4 days, usually, is the maximum). You also get to name the file and add some key words to let folks know what the file is about.

A utility comes with PB/PG to add the file header. Just run PFHADD (for Pacsat File Header Add) followed by a space and your file name. A menu comes up on the screen and takes you though the steps to get the header correct. It's almost impossible to make a mistake. When the PFHADD is done, it reports to you that the file has been duplicated in your directory with the extension .OUT.

For normal non-automatic operation, the next time the satellite comes up over the horizon, run the program PG and select from the screen display UPLOAD. The next part will make you nervous the first time you do it. It goes so fast. Your station will automatically connect with the satellite, upload the message file, report to you the speed of the transfer, and tell you if the transfer was successful. If activity is light on the satellite at the time, this could take as long as 4 seconds for a typical file size of about 1k. When the transfer is complete, your computer will beep. Exit PG and run PB to start downloading files and directories, as mentioned in last months issue of *Satellite Operator.*

If your file transfer was not completed for some reason, the satellite will tell you why it didn't completely upload and will make another attempt (if the satellite is still above the horizon). Both your station and the satellite must acknowledge the completion of the file transfer (it's

automatic). Sometimes the confirmation of the transfer doesn't make it because, for instance, there could be interference on the channel. Or the satellite's signal could fade at exactly the wrong time, or the satellite could go down over the horizon (LOS).

No matter what the reason for transfer failure, your system will hold the message for the next available time to complete the upload. Take the example of the large file sent by KB2MVN to W1XT. That was uploaded in segments. The satellite always remembers how much of the file it has received and tells your station what parts it needs. Your station complies . . . automatically. No part of any upload or download is redundant.

You might wonder how often a relatively small file upload doesn't complete the first try. Actually it's rare. Once you connect with the satellite, you can be pretty sure the upload will be successful in very short order.

What's the lure to these digital satellites?

Just like most of Amateur Radio, you can "read the mail." In the case of the digital Birds, you are actually reading the mail. Any message traffic that's posted to the satellite for store-and-forward handling can be read by anyone. The trick is not to see if you can read everything, because you can't (not easily, anyway). There's too much. You need to be selective about what you want to see before flagging it for download or you'll have far too much to read, and fill up your hard drive in the process.

Typically you would flag for download those messages on subjects in which you have an interest. Much of the traffic is about working the Microsats, using the software, making equipment work correctly, and DX. Some is personal in nature between friends. After watching the file names for a while, you'll get a good idea of what you want to see and what is of no interest. You might, for instance, want to see Keplerian elements when posted. You might also like to see any bulletins. If you are a DXer, you would certainly want to keep an eye out for announcements.

There are other things going on besides message traffic. Software programs are uploaded and downloaded which can be used to improve station performance. Some operators exchange photos like the one from KB2MVN pictured earlier. There are even a few who are exchanging digitized voice messages.

DXing the Digital Birds

DXing is happening on the Microsats as it does on OSCAR 13 and the HF bands. It may take a bit of a different slant, however. Competition, such as that found in contesting on the HF bands happens, too. It's especially true when several stations in a local area are all on the same satellite at the same time. It can be like working a pile up. To get AOS and find a buddy down the street already in the queue for downloading directories or files can get ones pulse to go up a bit. Bigger or higher antennas? More power? Better preamp? Better coax? All of the above? Most folks probably won't admit it, but there is a little competition for access to these Birds — just in a much more subtle way than on HF or OSCAR 13!

Another interesting aspect of DXing these satellites is to attempt using them on very low elevation passes. Connecting with KO-23 when it is less than a half degree above the horizon and capturing a message file addressed to you is one of the bigger thrills of working these LEO satellites. Pulling a file off when the satellite is actually below the horizon is even more fun. Doing that takes some effort, and a finely tuned station. And it doesn't happen too often.

Next time

In the next issue we'll look at some of the hardware and software folks are using to automate their stations. And we'll try to identify some of the stumbling blocks facing a few would-be operators. If you have run into a "brick wall," please write us. We'll publish some of the problems and see if we can't get some answers for you from the experts already using the digital satellites. ♦♦♦

Modifications to the Radio Shack HTX-100

In a recent issue of OSCAR Satellite Report *(February 15), we mentioned the availability of the Radio Shack 10-meter transceiver at a bargain basement close-out price. Using this unit for the satellites is probably not difficult. Detailed information has appeared over the years for connecting VHF/UHF transverters but it may have been missed by the most recent buyers of this neat little package. We reprint the information for all those who may have missed it, as it was posted recently by KD2BD to Internet.*

By John A. Magliacane, KD2BD

Due to the number of responses to my earlier comments on this subject, the following information is offered. It includes detailed information on using the Uniden HR2600 (and similar 10-meter transceivers) with linear transverters for VHF/UHF and possible OSCAR operation.

My QRP modification first appeared on Amateur Packet Radio in November of 1990. It was then picked up by Bud Stacey, KC4HGH, who included it his *Uniden Cookbook*, which covers handy modifications for the Uniden HR2510, HR2600, Lincoln (Export), and Realistic HTX-100 transceivers. My article is as follows:

"I recently purchased a Uniden HR2600 and Microwave Modules MMT 144/28 2-meter linear transverter and got both interfaced and working well. The HR2600 has an output power of 25 watts PEP on SSB, CW and 10 watts on AM/FM. The transverter requires only 0.25 to 25 mW of 28 MHz drive for proper operation. In an effort to reduce the HR2600 output level to the level required by the transverter, I removed PB-100, a small, double-sided copper circuit board located under the top cover that supplies +Vcc to the driver and final amplifier stages. I then soldered a jumper between TP2 and TP4, the outermost prongs that hold PB-100 in place.

This action supplies the HR2600 driver with full +Vcc, but removes +Vcc from the MRF477 final power amplifier. There is more than enough driver energy fed through the final to

(Continued on page 12)

A Meeting in Morocco

In OSCAR Satellite Report *Number 263 we ran a photo of Jim, KK3K, and Ahmed, CN8GI. That photo was used on the license for Jim, when he received CN2JM. His story of the trip follows.*

By Jim Kelly, KK3K

On Saturday evening, December 26, 1992, my life partner Dan and I boarded a Royal Air Maroc flight in New York bound for Casablanca, Morocco. It was the beginning of our 15 day extensive tour of Morocco during which we would cover 1500 miles. We visited the imperial cities of Casablanca, Rabat, Fez and Marrakesh, and enjoyed the beautiful scenery while traversing Morocco's three mountain ranges and the Moroccan Sahara. The scenery was spectacular; Moroccan art and architecture is beautiful; and the food was delicious.

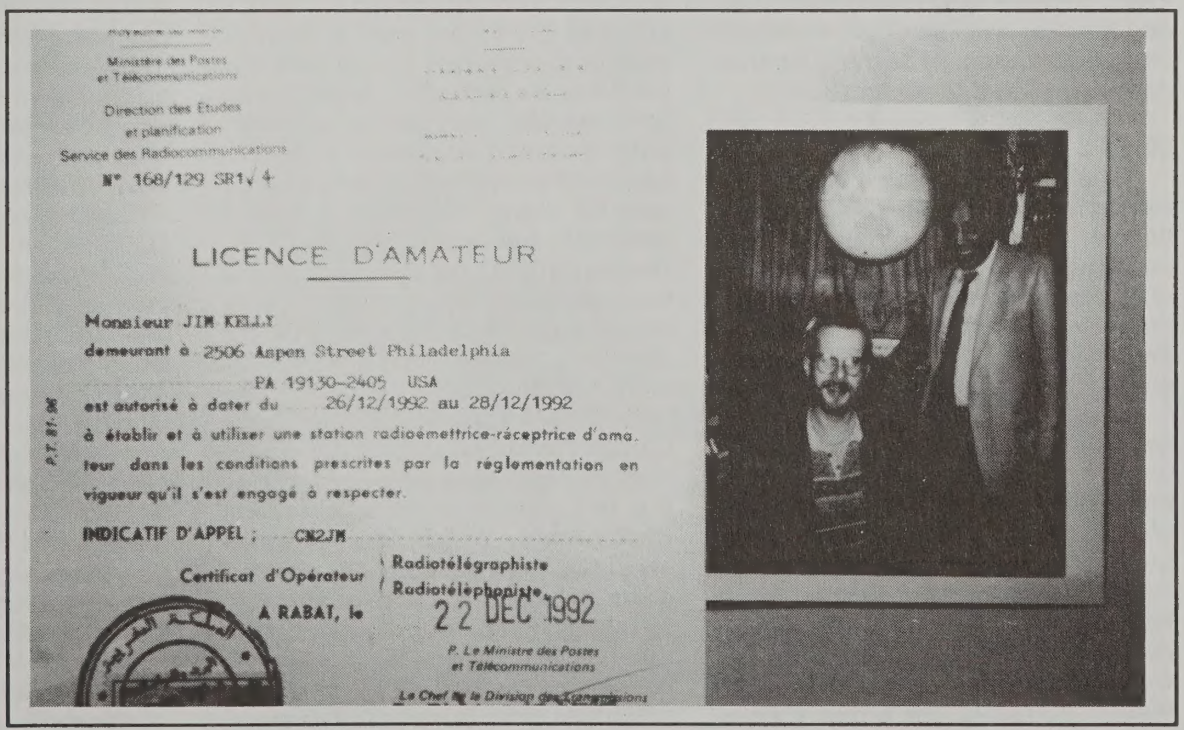
Many OSCAR 13 DX enthusiasts have had the pleasure of chatting with Dr. Ahmed Boudda, CN8GI, who is a regular on the transponder. Ahmed lives in Rabat, the capital city of Morocco. When Dan and I decided to holiday in Morocco, I wrote to Ahmed to inquire as to the possibility of meeting for an "eyeball QSO" during our one day visit to Rabat. While Ahmed is well liked and respected on the transponder due to his friendly manner and generosity, I had no idea that he would go to so much trouble to extend the best Moroccan hospitality to Dan and I. Ahmed asked me to send him a photocopy of my FCC license which I did. He then secured for me ahead of time a license to operate while in Morocco using the call sign CN2JM. The "JM" stood for "Jim in Morocco!" Ahmed invited Dan and I dine with him at his home, and invited me to operate on OSCAR 13 using his station after dinner.

When we arrived at our hotel in Rabat, Ahmed was waiting for us. Ahmed drove us to his home in Rabat, where we enjoyed a special treat: an authentic Moroccan home cooked dinner. Ahmed introduced us to his son Yusef who is a business school student. We chatted over a glass of Moroccan mint tea, then we enjoyed a sumptuous dinner consisting of a vegetable couscous followed by a chicken "tagine" or stew prepared with olives, raisins and pickled lemons. For dessert we enjoyed fruit including some of the delicious oranges grown all over Morocco.

After dinner Ahmed allowed me to operate on OSCAR 13 from his well appointed shack. He provided me with several cups of strong Moroccan coffee, similar to espresso, which enabled me to properly log all of my contacts even though Dan and I had not slept in 32 hours. I logged 72 contacts in 20 different countries in one and a half hours! I wanted to operate longer, however, we knew we had to get some rest since we were set to depart for Fez early the next morning.

Meeting someone in person that you've befriended via Ham Radio is always a special treat. However, Ahmed made our "Meeting in Morocco" extra special by being so gracious and generous. On behalf of Dan and myself, I'd like to once again thank Ahmed and his family for making our visit to Morocco especially memorable.

Editor's Note: KK3K and a few other members of the Lambda Amateur Radio Club are, at about the time you receive this issue, going to be operating from a "new" country for the satellites on OSCAR 13. See OSCAR Satellite Report *Number 264, page 3 for details.* ♦♦♦



Ministère des Postes et Télécommunications
Direction des Etudes et planification
Service des Radiocommunications
N° 168/129 SR1√4

LICENCE D'AMATEUR

Monsieur JIM KELLY
demeurant à 2506 Aspen Street Philadelphia
PA 19130-2405 USA
est autorisé à dater du 26/12/1992 au 28/12/1992
à établir et à utiliser une station radioémettrice-réceptrice d'amateur dans les conditions prescrites par la réglementation en vigueur qu'il s'est engagé à respecter.

INDICATIF D'APPEL : CN2JM

Certificat d'Opérateur Radiotélégraphiste / Radiotéléphoniste

A RABAT, le 22 DEC 1992

P. Le Ministre des Postes et Télécommunications
Le Chef de la Division des Radiocommunications

Jim, KK3K, sent us this photo of the license he received for CN2JM. The photograph is rather dark in the original and doesn't reproduce well here.

The STS-55 SAREX Mission

A final review of the STS-55 Mission is given here. As most folks know, the mission has had several delays, the most recent of which moves the launch to no earlier than March 19, 1993. For later developments, watch OSCAR Satellite Report *or sign up for our FAX Shuttle Update program. Call, write, or FAX R. Myers Communications for details. The information is in the box on page 12 of this issue.*

The SAREX team has been working diligently behind the scenes to provide another "frequent flyer" year for SAREX operations. Currently, three SAREX missions are manifested to be flown in 1993. In addition, there is a distinct possibility that two additional flights may be manifested later in the year. If this occurs, we will have five SAREX flights this year!

Three back-to-back SAREX missions are currently slated in 1993. These include the STS-55 space shuttle Columbia flight which will carry the German Spacelab module into orbit, the STS-56 shuttle Discovery flight carrying the Atmospheric Laboratory for Applications and Sciences (ATLAS-2) spacelab payload and the STS-57 shuttle Endeavour flight which will carry the new Spacelab module and will be in a low (28.5 deg) inclination orbit. High latitude cities in the U.S. and Europe will have low elevation passes (less than 10 degrees) for this mission.

STS-55 Details

The STS-55 flight is a 9 day mission and is the first spacelab module flight of 1993. It is designated SL-D2 and represents the second in a series of dedicated flights for Germany. The primary goals of this mission are to perform studies in materials and life sciences research.

SAREX configuration C was selected for this mission. Configuration C includes 2M FM voice and 2M FM packet. Four of the seven STS-55 crew members are licensed. These include Commander Steve Nagel, N5RAW, Payload Commander Jerry Ross, N5SCW, German Payload Specialist Hans Schlegel, DG1KIH, and German Payload Specialist Ulrich Walter, DG1KIM. The primary voice call sign will be N5RAW. The packet radio call sign for this mission (and all missions in '93) is W5RRR-1. Nine U.S. and five foreign school groups have been selected for direct contacts on this flight. Since this will be a low inclination orbit, the teleconference bridge will be used for school contacts.

In addition to the U.S. SAREX ham gear in the Shuttle mid-deck, an additional Ham Radio station will be flown in the German spacelab module. This station, designated SAFEX (for *Spacelab Amateurfunk-Experiment*), includes a 2M FM downlink and a 70-cm FM uplink capability. A dual band (2M/70cm) external antenna, mounted on the German spacelab module, will be used for SAFEX contacts. Payload Specialists Schlegel and Walter expect to make a few scheduled contacts with European schools with this equipment.

The externally mounted SAFEX antenna gives the SAREX team a unique opportunity to compare the performance of the U.S. SAREX window mounted antenna to an externally mounted antenna. A special antenna test is planned on Orbits 61 and 62 using the normal SAREX downlink frequency, 145.55 MHz. During Orbit 61 the shuttle crew will transmit using the SAREX window mounted antenna. On orbit 62 the crew will transmit using the externally mounted SAFEX antenna. Members of the Motorola Amateur Radio Club in Florida will conduct extensive field strength measurements during the two passes to evaluate system performance. In addition, individuals in the Southeastern U.S. are welcome to help participate in this test by taking signal strength readings of the received signal for both orbit passes in your area. If the shuttle is well above your horizon (10 degrees) for both passes and antenna obstruction is not a problem at your QTH, we solicit your support.

SAREX Frequencies

The Shuttle uplink frequencies have changed somewhat since the last SAREX flight. As in the past, split Uplink/Downlink frequencies are being used for this mission with a primary, worldwide downlink frequency of 145.55 MHz. The Astronauts will not favor any of the uplink frequencies, so your ability to establish contact with the Shuttle crew will be somewhat the "luck of the draw." Notice that different uplink frequencies have been chosen for Europe and the rest of the World. Please remember that the crew will not be operating in a simplex mode, so do not transmit on the downlink frequency of 145.55 MHz.

Information Bulletins

Several bulletin stations will be available, some around the clock, to provide up-to-the-minute SAREX information. These include the Goddard Space Flight Center ARC (WA3NAN) in Greenbelt, MD, the Johnson Space Center ARC (W5RRR) in Houston TX, and the American Radio Relay League Station (W1AW) in Newington, CT. W1AW will broadcast SAREX bulletins as part of its normal daily bulletin service. WA3NAN plans to operate around the clock during the entire mission, providing Keplerian Elements, SAREX operating schedules, frequency reminders, and other general SAREX information. In addition, WA3NAN will broadcast Live Space Shuttle air-to-ground audio throughout the mission. WA3NAN plans to use the following frequencies: 3.860 MHz, 7.185 MHz, 14.295 MHz, 21.395 MHz and 28.650 MHz on HF and on 147.45 MHz on VHF in the Washington D.C. area. W5RRR will provide news bulletins and answer questions on HF when operators are available. W5RRR plans to use the following frequencies: 3.850 MHz, 7.227 MHz, 14.280 MHz, 21.350 MHz and 28.400 MHz on HF and on 146.64 MHz on VHF in the Houston, TX area. In addition to the above sources, information will be disseminated world-wide via packet and on INTERNET.

Keplerian Elements

During the mission, orbit param-

eters can be obtained via packet radio, via INTERNET, through the Goddard Amateur Radio Club's Shuttle Retransmissions, through bulletins from the ARRL's W1AW station, and via the JSC Radio Club Station, W5RRR.

QSLs

As with all SAREX flights, a special QSL card is planned for each SAREX mission. If you make a 2-way contact with the crew or hear the SAREX downlink, you qualify for a QSL card for that mission.

The IBM Amateur Radio Club of Boca Raton, Florida has volunteered to act as the QSL manager for the STS-55 SAREX mission. For the STS-55 mission, please send your QSLs to: IBM Amateur Radio Club/1993, PO Box 1328, Boca Raton, FL 33429-1328. On the outside of the envelope, please write STS-55 SWL or STS-55 QSL—2- Way, depending on whether you heard the downlink or made a two-way contact.

For all QSLs, it is essential that you include an SASE using a large (4 inch x 9.5 inch) envelope. If an SASE or sufficient IRCs are not included with your signal report you will not receive a QSL card. Please expect a lengthy (6-10 month) wait after the Shuttle mission to receive your QSL card. This wait is not due to our QSL manager volunteers. The development of a SAREX QSL card can be a very lengthy process. It is nearly one month before mission photos are available to the SAREX team. At this point, the card layout process can begin. Card layout, crew approval, and audio tape logging takes at least 2-3 months, sometimes longer. Card printing and shipment to the QSL manager takes approximately 2 months. In addition, QSL distribution usually takes approximately 2 months. Like other prized DX cards, please be patient for your card to arrive. Each SAREX QSL card has always proven itself to be worth the wait!

SAREX Payload Description and Mission Overview

Configuration C - SAREX configuration C consists of the handheld transceiver, I/F module, PGSC, spare battery set, window antenna, packet module, SAREX headset assembly, personal recorder, and the required cable assemblies. The packet module contains a power supply and packet TNC. The power supply provides power for the TNC and the handheld transceiver. The TNC interconnects with a radio transceiver so that data to and from the computer is transmitted to and received from other amateur radio stations. Configuration C is capable of operating in either the voice or data mode in communications with amateur stations within LOS of the Orbiter. This configuration can be operated in the attended mode for voice communication and either the attended or automatic mode for data communications.

Flight Operations

Operation in-flight will be limited to usage during off-duty hours by crew members who have Amateur Radio licenses.

Payload Control Parameters

The payload control weight for Configuration C is 45 lb. All Configuration C payload equipment, except the window antenna, will be stowed in one half locker volume. The window antenna will be stowed in the Orbiter window shade bag.

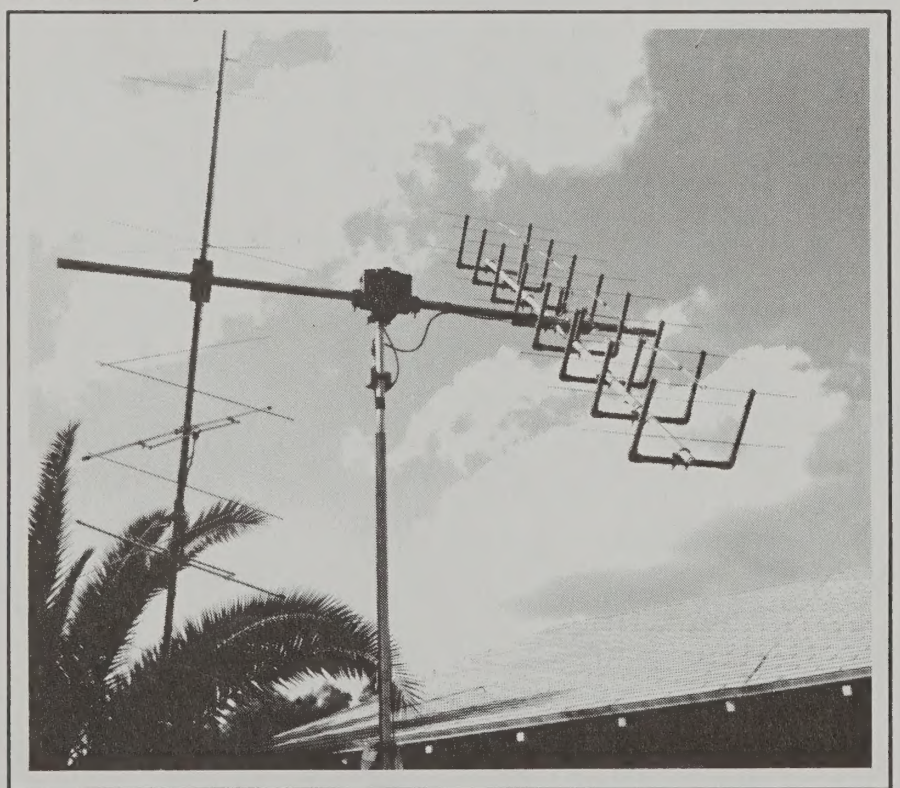
Launch Commit Criteria

On-orbit: All SAREX operations will be conducted in the 2 meter (144 to 146 MHz) band utilizing FM.

Operating times for the SAREX payload will be such as to not interfere with any other planned mission activities. The payload operating times will be logged via the standard crew personal tape recorder or the PGSC, as appropriate. The customer will identify the desired ground locations expected to be used for SAREX payload operations prior to the flight.

Editor's Note: Satellite Operator *would like to thank Frank Bauer, KA3HDO, and the American Radio Relay League's Educational Activities Department from where much of this information came.* ♦♦♦

On A Different Subject...



The OSCAR antennas at K7BZ (photo on page 1) use a KLM crossed Yagi for 2 meters but a homebuilt broadside array for 70 cm. This antenna exhibits a broad horizontal pattern but a very sharp vertical one. Changing elevation by 20 degrees makes a big change in signal strength. One advantage of this style of antenna is that when pointed above 20 or 30 degrees elevation, power line and other ground noise is reduced. The disadvantage is that the 70 cm antenna must be pointed accurately or you'll hear others but not your own downlink signal! — Photo by W1XT.

Weak Signal Source (from page 6)

One of the things that can cause the preamp to degrade your signal-to-noise ratio is a faulty preamp device. Or it can be caused by a bad connector that was bypassed when the preamp was removed from the line. But sometimes manufacturers place filters ahead of the preamp device to help prevent out-of-band signals from overloading it. This kind of overload is troublesome in large metropolitan areas or when you're located near some high powered transmitter.

That filter may be lossy. It may have more loss that a straight run of coax from your antenna to your receiver. In this case, you are actually better off without a preamp. It's worth checking out if you do any weak-signal reception.

Another thing you can do with this oscillator is place it in the highest tree you can find so that you can rotate your antenna back and forth past it to see what your antenna pattern looks like. You can check your front-to-back ratio although that's not critical in satellite work. You can also get an idea about the vertical pattern of your antenna and how careful you need to be with your pointing.

The nice thing about having an oscillator like this is you can make your own "satellite signal" anytime to test antennas, preamps, coax or whatever. It provides a constant signal level with which to work.

If you build one of these, please send us a photo. We'd like to know what you learn about your station, antennas, and preamp. Anyone care to try one of these for 435 MHz? Tell us about it. ♦♦♦

Radio Shack HTX-100 (from page 8)

excite the transverter in this configuration. I've received good signal and audio reports from all the locals when using the transverter and the HR2600 with this simple modification. I believe this modification could make the HR2600 usable with other transverters as well."

KC4HGH added some comments indicating that the HR2510/Lincoln and HTX-100 all have the same shorting printed circuit board supplying +Vcc the driver and final amplifiers, so these rigs should be just as easy to convert to QRP levels as the HR2600. Incidentally, the PB-100 shorting strip is used to measure driver and final amplifier collector current when troubleshooting the rig.

I have not measured the reduced output power level once the final has been disabled. For what it's worth, the MRF477 final power transistor requires 400 mW of drive to produce 25 watts of output power. The rig cannot produce AM modulation once the final amplifier has been disabled. However it does receive in the AM mode, which is useful when using a gated noise source for optimizing low-noise preamplifiers. The transmitter ALC is also disabled, so be careful not to overdrive the transmitter and transverter.

It is also helpful to run a PTT line from the 10-meter rig to "hard key" the transverter, rather than rely on RF RX/TX switching. I received several audio reports from people who thought I was using VOX since I was not hard keying the transverter. ♦♦♦

Satellite Operator

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Orbital Elements for Non-OSCAR Satellites

Data Courtesy of Dick Campbell, N3FKV March 5, 1993

Satellite: NOAA-9
Catalog number: 15427
Epoch time: 93064.09468329
Element set: 311
Inclination: 99.1157 deg
RA of node: 102.4204 deg
Eccentricity: 0.0015857
Arg of perigee: 101.3274 deg
Mean anomaly: 258.9708 deg
Mean motion: 14.13485778 rev/day
Decay rate: 4.2e-07 rev/day^2
Epoch rev: 42407
Checksum: 306

Satellite: NOAA-10
Catalog number: 16969
Epoch time: 93063.99532053
Element set: 158
Inclination: 98.5229 deg
RA of node: 82.0725 deg
Eccentricity: 0.0012257
Arg of perigee: 260.2898 deg
Mean anomaly: 99.6915 deg
Mean motion: 14.24771441 rev/day
Decay rate: 1.74e-06 rev/day^2
Epoch rev: 33579
Checksum: 337

Satellite: MET-2/17
Catalog number: 18820
Epoch time: 93062.11224583
Element set: 854
Inclination: 82.5427 deg
RA of node: 283.2922 deg
Eccentricity: 0.0018081
Arg of perigee: 63.8992 deg
Mean anomaly: 296.4026 deg
Mean motion: 13.84675358 rev/day
Decay rate: 7.2e-07 rev/day^2
Epoch rev: 25716
Checksum: 323

Satellite: MET-3/2
Catalog number: 19336
Epoch time: 93059.17117010
Element set: 24
Inclination: 82.5449 deg
RA of node: 299.1076 deg
Eccentricity: 0.0018813
Arg of perigee: 10.2499 deg
Mean anomaly: 349.9003 deg
Mean motion: 13.16955895 rev/day
Decay rate: 4.3e-07 rev/day^2
Epoch rev: 22086
Checksum: 305

Satellite: NOAA-11
Catalog number: 19531
Epoch time: 93063.92610455
Element set: 63
Inclination: 99.1197 deg
RA of node: 37.7205 deg
Eccentricity: 0.0012369
Arg of perigee: 15.8898 deg
Mean anomaly: 344.2633 deg
Mean motion: 14.12834641 rev/day
Decay rate: 2.24e-06 rev/day^2
Epoch rev: 22895
Checksum: 306

Satellite: MET-2/18
Catalog number: 19851
Epoch time: 93042.82302713
Element set: 795
Inclination: 82.5205 deg
RA of node: 174.8553 deg
Eccentricity: 0.0014499
Arg of perigee: 158.1592 deg
Mean anomaly: 202.0188 deg
Mean motion: 13.84319416 rev/day
Decay rate: 1.00e-06 rev/day^2
Epoch rev: 19984
Checksum: 316

Satellite: MET-3/3
Catalog number: 20305
Epoch time: 93061.52599304
Element set: 698
Inclination: 82.5460 deg
RA of node: 240.0985 deg
Eccentricity: 0.0017031
Arg of perigee: 24.1695 deg
Mean anomaly: 336.0249 deg
Mean motion: 13.16009688 rev/day
Decay rate: 4.3e-07 rev/day^2
Epoch rev: 16107
Checksum: 289

Satellite: MET-2/19
Catalog number: 20670
Epoch time: 93053.54452869
Element set: 546
Inclination: 82.5435 deg
RA of node: 229.4266 deg
Eccentricity: 0.0017012
Arg of perigee: 53.7778 deg
Mean anomaly: 306.4951 deg
Mean motion: 13.84161285 rev/day
Decay rate: 5.9e-07 rev/day^2
Epoch rev: 13426
Checksum: 319

Satellite: FY-1/2
Catalog number: 20788
Epoch time: 93064.01346360
Element set: 526
Inclination: 98.8712 deg
RA of node: 93.2872 deg
Eccentricity: 0.0013565
Arg of perigee: 232.3263 deg
Mean anomaly: 127.6674 deg
Mean motion: 14.01278112 rev/day
Decay rate: 1.66e-06 rev/day^2
Epoch rev: 12799
Checksum: 304

Satellite: MET-2/20
Catalog number: 20826
Epoch time: 93055.79438171
Element set: 0552
Inclination: 082.5283 deg
RA of node: 165.8042 deg
Eccentricity: 0.0012617
Arg of perigee: 307.7591 deg
Mean anomaly: 052.2949 deg
Mean motion: 13.83534160 rev/day
Decay rate: 7.3e-07 rev/day^2
Epoch rev: 12174
Checksum: 300

Satellite: MET-3/4
Catalog number: 21232
Epoch time: 93047.31150673
Element set: 349
Inclination: 82.5471 deg
RA of node: 153.2127 deg
Eccentricity: 0.0018161
Arg of perigee: 334.4273 deg
Mean anomaly: 25.5954 deg
Mean motion: 13.16819124 rev/day
Decay rate: 4.3e-07 rev/day^2
Epoch rev: 8741
Checksum: 277

Satellite: NOAA-12
Catalog number: 21263
Epoch time: 93064.04785407
Element set: 518
Inclination: 98.6689 deg
RA of node: 95.9545 deg
Eccentricity: 0.0013342
Arg of perigee: 152.4113 deg
Mean anomaly: 207.7789 deg
Mean motion: 14.22209259 rev/day
Decay rate: 2.25e-06 rev/day^2
Epoch rev: 9384
Checksum: 320